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Disposal of Garbage Aboard RAN Ships - A Review of Possible Options

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DEPARTMENT OF DEFENCE
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ABSTRACT

The RAN is implementing procedures to dispose of shipborne waste based on national legislation in order to meet International Maritime Organization (IMO) requirements. The regulations, which only apply to navies when operational commitments allow, cover a number of categories of waste, including garbage. A summary of the RAN disposal regulations applying to various types of garbage and estimates of the amounts generated on the various ships are included. Existing garbage disposal equipment and procedures employed by the RAN and some research conducted by other navies have been reviewed. The processes available for disposal of garbage aboard ships have been studied and the design constraints applying to shipboard installations summarised. A comprehensive survey of garbage processing machinery that included thermal compactors for plastics materials, shredders, compactors, comminuters and incinerators was also conducted. The most promising machines for use by the RAN are discussed and recommendations for future actions by AMRL and the RAN are made.

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Executive Summary

The RAN is implementing procedures to dispose of shipborne waste based on national legislation in order to meet International Maritime Organization (IMO) requirements. The regulations, which only apply to navies when operational commitments allow, cover a number of categories of waste, including garbage. This laboratory has undertaken a programme to assess the scope of the requirement and suggest possible approaches for coping with waste disposal onboard naval vessels. As a first step in addressing the problem a list of the various types of RAN ships and their complements has been compiled and an estimate of the daily garbage accumulation rates made. This was based on USN data and a survey of food waste on RAN ships. These rates varied from 1235 kg/day for a Training and Helicopter Support Ship (amphibious mode) down to 15 kg/day for smaller craft such as Auxiliary Minesweepers. Such information provides a basis for making waste management decisions and for selecting appropriate machinery with an adequate waste processing rate. Existing navy garbage disposal equipment and procedures were reviewed and a literature search on marine waste disposal conducted to determine how other navies were approaching the problem. The processes available for disposal of garbage aboard ships have been studied and the design constraints applying to shipboard installations summarised. A comprehensive survey of garbage disposal machinery suitable for use by ships was conducted and the technical details of this equipment tabulated. The most promising machines for use by the RAN are discussed and recommendations for future actions by AMRL and the RAN are made.

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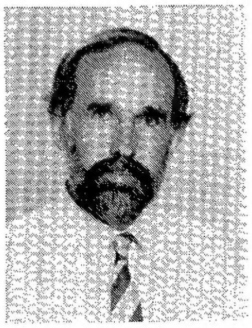

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Contents

1. Introduction

The RAN policy for the disposal of shipborne waste [1] is based on national legislation that requires international maritime requirements to be met where operational commitments allow. The regulations are defined by the International Maritime Organization (IMO) convention: The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978, also referred to as "MARPOL 73/78" or "MARPOL". There are currently five Annexes to MARPOL: I-Oil, II-Noxious Liquids, III-Harmful Packages, IV-Sewage and V-Garbage. Australia became a signatory to Annexes I, II and V of the Convention by the passing of the Protection of the Sea (Prevention of Pollution from Ships) Act, 1983.

The MARPOL regulations prohibit the dumping overboard of plastics waste anywhere at sea. This requirement prompted a review of the situation by this laboratory which issued a summary of strategies for disposal of plastics waste at sea [2] covering 'Source Reduction', 'Incineration', 'Mechanical Alteration' and 'Biodegradable Polymers'. This review recommended an integrated approach since no single option could solve all aspects of the naval plastics waste problem. The immediate strategy suggested was to reduce the bulk of the wastes by combining source reduction with waste 'densification'. Biodegradable polymers, for use in food storage and catering, may be developed in the future. To reduce the bulk of waste plastics, a Thermal-Compactor, such as the Mobil 'Densifier,' was seen as a best option as it not only condensed the waste but also allegedly sterilised it for safe storage and disposal.
The initial objective of the present survey was to examine alternative systems for minimising the bulk of plastics waste so that it could be safely stored pending shore disposal. However, when it became apparent that most garbage processing machines were designed to process all types of solid waste, and that separation of plastics from the bulk waste was not easy, the scope was widened to encompass the disposal of all shipboard garbage. Furthermore, trends are towards minimal disposal of waste at sea [3] and already there are a significant number of declared 'Special Areas' where stringent waste disposal requirements apply. The Great Barrier Reef Region has been designated a 'Particularly Sensitive Sea Area' and here no garbage of any type may be discharged [refer Table 1).

Further justification for considering processing of garbage collectively is that: (a) some packaging is a composite of plastics and cardboard (eg. milk cartons), (b) a space saving would be achieved by installing one machine capable of processing all solid waste including plastics, (c) the RAN often operates in the GBR Region, and (d) retention of garbage aboard would remove any possibility of an identifying 'garbage signature' in time of conflict.

The approach adopted has involved a survey of aspects such as classification and quantity of waste involved, existing RAN garbage disposal equipment and procedures, alternative disposal processes, design considerations and constraints, and overseas experience. This information provided an overall design profile for the machinery

required including such parameters as processing capacity, dimensions, weight, construction materials, electrical and power requirements. Finally, a survey of relevant local and overseas commercial machinery was completed. The most promising machines for use by the RAN are discussed and recommendations for future actions by AMRL and The RAN made.

2. The RAN Garbage Disposal Policy.

The RAN policy on disposal of garbage [1] is broadly based on MARPOL 73/78, Annex V, and is summarised in the following Table.

Table 1:Regulations for Disposal of Garbage at Sea from all RAN Ships and Support Craft. (Table taken from DI(N) OPS 19-1).

Area **Garbage Type**	**Outside Special Area and the GBR Region**	**Within GBR Region**	**Within Special Area (1)**
All plastics	**Prohibited**	**Prohibited**	**Prohibited**
Garbage that floats (excluding paper, cardboard and food waste)	**Prohibited**	**Prohibited**	**Prohibited**
Paper and cardboard, not plastic or wax coated, and not comminuted or ground	Acceptable > 25 n mile from nearest land and the GBR Region	**Prohibited**	**Prohibited**
Paper and cardboard comminuted or ground	Acceptable > 3 n mile from nearest land and the GBR Region	**Prohibited**	**Prohibited**
Glass, metal, bottles, crockery & similar garbage that will sink straight away on discharge.	Acceptable > 12 n mile from nearest land and the GBR Region	**Prohibited**	**Prohibited**
Food waste not comminuted or ground	Acceptable > 12 n mile from nearest land and the GBR Region	**Prohibited**	Acceptable > 12 n mile from nearest land
Food waste comminuted or ground*	Acceptable > 3 n mile from nearest land and the GBR Region	**Prohibited**	Acceptable > 12 n mile from nearest land
Mixed garbage type	The garbage shall be handled as if it consists solely of the component which has the most stringent requirement		

* To be able to pass through a mesh size no larger than 25 mm.

(1) Areas currently declared as 'Special Areas' are: The Mediterranean Sea, The Baltic Sea, The Black Sea, The Red Sea, The Gulfs Area (Persian and Oman), The Gulf of Aden, Antarctica (South of 60° S), The North Sea Area and The Wider Caribbean Region. The Great Barrier Reef (GBR) is defined as a 'Particularly Sensitive Area' by IMO which affords it greater protection than Special Areas.

3. Classification and Quantity of Shipboard Garbage.

The quantity and classification of shipboard garbage generated during typical missions needs to be known so that appropriate management methods and the type and processing capacity of machinery can be determined. Although there is some information available from surveys of USN and RN ships there is a need for the RAN to conduct its own survey as there are significant differences between the RAN operation and the USN/RN, and time will have brought changes in packaging materials and methods. Furthermore, as a result of the rapidly changing policy concerning dumping of garbage at sea, efforts are now being made by navies to reduce the amount of packaging brought aboard during provisioning.

A 1987 survey [4] found that U.S. Navy ships at sea generate over 1.43 kg of solid waste per person per day. By weight, this was composed of 41% food waste, 35% paper and cardboard, 17% metal and glass and other wastes, and 7% plastics. Typically, about half of the plastics waste generated aboard ship was related to food service operations, primarily from food packaging. It was found that after three days of storage aboard ship residual food left on this plastics waste created extremely unpleasant odour and sanitation problems. However, retaining plastic waste generated outside the food service operation was a relatively easy task and the most critical 'success factor' was providing 'plastics only' waste receptacles next to every existing garbage bin.

There has been little apparent research into the rate of generation of food waste in ships. A widely quoted generation rate is 0.58 kg/p.day derived from the above study [4]. However this is an unreliable figure because the data was collected from only one ship over a 32 hour period, and food waste disposed directly to sea through garbage grinders was not included in the audit. Furthermore, the USN has menus and catering techniques distinct from those employed in the RAN.

A 1995 survey [5] of six RAN ships with crews ranging from 15 to 220 found that per capita food waste generation rate was related to crew size. The study concluded that, while a definitive function could not be derived, a reasonable estimate of per capita generation rate is about 0.6 kg/p.day for crews up to about 30, and about 0.95 kg/p.day for crews of around 200. Actual daily per capita generation rates fluctuated more widely in smaller crews. Estimates for crews greater than about 250 are based on extrapolation of the data and are therefore more speculative. A rate of about 1 kg/p.day is a reasonable assumption for larger crews, although the actual rate may be in excess of this.

Combined USN and RAN garbage generation rates from the above surveys have indicated the following values.
Total garbage generated 1.9 kg/p.day on large ships (crew > 30) and 1.5 kg/p.day on smaller ships (crew < 30) comprising:

(a) food waste - 1.0 kg (large RAN ships) and 0.6 kg (smaller RAN ships)- with an assumed loose stowage volume of 600 kg/m^3;
(b) plastics - 0.1 kg - with an assumed loose stowage volume of 12 kg/m^3;
(c) tins, bottles etc. - 0.3 kg - with an assumed loose stowage volume of 250 kg/m^3;
(d) paper, cardboard etc. - 0.5 kg - with an assumed loose stowage volume of 40 kg/m^3.

The above rates, together with crew complements, have been applied to the various ships of the RAN to estimate the amount of garbage that needs to be processed per day. The maximum mission times expected for each class of ship can be used to estimate the total amount of garbage involved while median mission times, calculated from ships underway records [6], provide a guide as to the more typical quantities. These figures are presented in Table 2 that includes all relevant RAN vessels and their complements listed by Jane's Fighting Ships [7] supplemented by additional information from various RAN staff and the booklet 'The Royal Australian Navy'. The Table provides a basis for an estimation of the processing capacity of garbage handling equipment required, the mix of materials involved and the storage volume needed for the processed product. This information was used when considering the suitability of available garbage processing machinery later in this report. Obviously some of the smaller craft, particularly those with usually short mission times, will not warrant fitment with extensive garbage handling facilities.

Table 2: RAN Ships Details and Estimated Garbage Accumulation.

Type[1]	Class[1]	No.[1]	Complement[1] incl. air crew & trainees	Plastics[2] (0.1 kg)	Food[3] (compl. < 30) (0.6 kg)	Food[3] (compl. > 30) (1.0 kg)	Bottles[2], tins etc. (0.3 kg)	Cardboard[2] paper etc. (0.5 kg)	Total garbage per day	Median[4] [5] mission time	Maximum[5] mission time
				Daily accumulation by category (kg/person.day) — Total Daily Accumulation for Ship							
				(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(days)	(days)
Submarine	Collins	0 + 6	50	5		50	15	25	95	[5]	25
Submarine	Oberon	3	77	8		77	23	39	146	[5]	25
Destroyer	DDG's	3	333	33		333	100	167	633	5	25
Destroyer	D.E.	2	220	22		220	66	110	418	4	8
Frigates	FFG-7	6	220	22		220	66	110	418	5	25
Frigates	Anzac	0 + 8	163	16		163	49	82	310	[5]	25
Patrol Craft (small)	FCPB	15	22	2	13		7	11	33	5	10
Patrol Craft (large)	OPC	0+9	72	7		72	22	36	137	[5]	22
Minehunters (inshore)	MHI	2	13	1	8		4	7	20	1	10
Minehunters (coastal)	MHC	0+6	35	4		35	11	18	67	[5]	20
Minesweeper	COOP	5	10	1	6		3	5	15	2	9
Amphibious	(Tobruk)	1	130	13		130	39	65	247	5	15
Heavy Lift			plus 550 troops	55		550	165	275	1045		
Training & Helicopter	(Manoora & Kanimbla)	2	200 (crew)	20		200.0	60	100	380	[30]	90
Support Ship			315 (training)	32		315.0	95	158	599	[14]	21
			650 (amphib.)	65		650.0	195	325	1235	[5-10]	15
Landing Craft (Heavy)	LCH	5	13	1	8		4	7	20	3	15

Table 2 continued next page

Table 2 (Continued): RAN Ships Details and Estimated Garbage Accumulation.

Type[1]	Class[1]	No.[1]	Complement[1] incl. air crew & trainees	Plastics[2] (0.1 kg)	Food[3] (compl. < 30) (0.6 kg)	Food[3] (compl. > 30) (1.0 kg)	Bottles[2], tins etc. (0.3 kg)	Cardboard[2] paper etc. (0.5 kg)	Total garbage per day	Median[4] [5] mission time	Maximum[5] mission time
				Daily accumulation by category (kg/person.day) — Total Daily Accumulation for Ship							
				(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(days)	(days)
Oceanographic	Moresby	1	146	15		146	44	73	277	4	22
	Flinders	1	38	4		38	11	19	72	4	22
New Hydrographic		0+2	49	5		49	15	25	93	[18]	28
Survey	SML	4	16	2	10		5	8	24	8	19
Auxiliary Tankers	(Westralia)	1	60	6		60	18	30	114	4	20
	(Success)	1	205	21		205	62	103	390	5	20
Submarine Trials & Safety	(Protector)	1	20	2	12		6	10	30	3	6

References:

1. (Ship Details) - Jane's Fighting Ships, 1993-94, 96th. Edn., ed. by Capt. Richard Sharp RN, plus amendments from the booklet 'The Royal Australian Navy' and other RAN Staff.
2. Schultz, Jon P., Upton 3, William K., Solid Waste Generation Survey Aboard USS O'Bannon (DD 987), David W. Taylor Naval Ship Research and Development Centre, Bethesda, MD 20084-5000, Research and Development Report DTRC/SME-87/92, February 1988.
3. Polglaze, John F., Characterisation of the Waste Stream and the On-site Vermicomposting of Food Wastes Generated in Ships of the Royal Australian Navy, School of Biological and Environmental Sciences, Murdoch University, Perth, Western Australia, 1995.
4. RAN Maritime Headquarters Minute 62/1/6-3 (Cmdr J. Carlin), Ships at Sea/Alongside Time Schedules for period 1/8/93 to 1/8/94
5. Times supplied by DNER-SS office, AFHEO (W.O. Longrigg) & other RAN Staff.

4. Existing Navy Garbage Disposal Equipment and Procedures.

The present status of garbage disposal within the RAN and RN has been reviewed as some equipment is already installed (or being installed as in the ANZAC frigates) and therefore some coordination with, or supplementation of this equipment, may be required. There are also cases of equipment installed in the past that has proved deficient and this has been documented to provide a comparison with any new machinery being considered. The following items are relevant to this investigation:

- The (Fox) Pollution Packer Model 1800 garbage compactor installed in HMAS Hobart (in 1992) was found to be useful for easing the garbage management problem in HMA ships [8] but in another report was found to be deficient [9]. (HMAS Hobart has a detailed waste management program outlined in HMAS Hobart Ships Standing Orders, Chapter 6, 'Environment Protection').
- An 'Elephant's Foot' compactor was installed in the scullery of the DDG HMAS Brisbane during the ships 1987 modernisation. It was considered unsatisfactory and subsequently removed. The same type of compactor was also installed on HMAS Parramatta as a trial in 1989. The machine was considered moderately effective but a number of deficiencies and limitations were reported [8].
- FFG's were originally fitted with Golar SK25M3 marine incinerators for disposal of waste oil and solid refuse. However they were removed several years ago as weight compensation for helicopter RAST modifications. 'Waste Hog' compactors were also removed for this reason [8].
- A Kelly Model 200/Batch incinerator is installed on the Amphibious Heavy Lift ship HMAS Tobruk but it is believed to be seldom used. It is a Pyrolytic type primarily intended for land based applications and suitable for solid waste only. A compactor (screw type, make unknown) was also installed on HMAS Tobruk but was also removed several years ago [8].
- A small portable incinerator, built by base staff, was installed on at least one of the DDG's prior to deployment in the Persian Gulf. It was little more than a 44 gallon drum that could pivot to empty the ash over the stern. It was used for the destruction of paper and cardboard and was considered by ships crew to be reasonably successful [8].
- The new ANZAC class frigates are being fitted with the 'Elephant's Foot' compactor that compresses both dry waste and waste containing a limited proportion of wet waste. It is housed in a special garbage disposal room allowing space for storage of the compacted waste sealed in plastic bags. Additionally these ships have a comminuter (manufactured by Hobart GMBH) which is located in another dedicated room adjacent to the galley. It processes food waste and is also capable of handling small amounts of disposable catering items such as plastics plates, knives and forks. The comminuted material passes through a water press producing an end product of semi-dry granules that can be stored in sealed bags for later disposal. The process water is continually recycled but at the end of the operation is classified as garbage and may be treated in the ships sewage system.

- In the RN it is reported [10] that some existing vessels and major vessels under construction are fitted with a range of commercial equipment. This equipment is considered to be not entirely satisfactory, being generally unreliable, labour intensive and difficult to operate and maintain. Much of it is also of insufficient capacity and, where the volume of garbage is high as in the CVS (aircraft carrier), the solution has been to provide several units of the same standard equipment. This places additional demands on already limited crew resources. Such equipment also does little for morale since much sorting of the garbage is necessary before being fed into the appropriate garbage processing equipment.

With minimum staffing of RAN ships being implemented, the above comments are real concerns and will have to be addressed when choosing equipment.

5. Survey of Overseas Procedures and Research

A search [11] was undertaken in order to review information relating to waste management in overseas navies.

The U.S. Navy's NAVSEA program for the future includes pulpers for carriers and large amphibious landing craft, and compactors, food waste disposers and plastics processors for all classes. The plastics waste processor is a hardware item that is expected to take 7-11 years to introduce on board their ships. This piece of equipment essentially heats plastics waste to a temperature where it can be reformed and extruded as blocks. Part of the design requirement is for the process temperature to be high enough to cook off any food residue, thus solving the putrefaction problem and allowing long term storage of the blocks. NSWC, Annapolis Detachment, is investigating use of a plastic bag that is an effective barrier to odour molecules. They have found that while a suitable resin exists (that meets this criterion) there are no bags presently manufactured with this material [12].

Further details of the equipment being developed for the U.S. Navy have been given by Smookler and Alig [13]. This includes a vertical compactor designed to compress non-food containing shipboard solid waste, including bottles, metal cans, cardboard and paper into slugs weighing from 30 to 50 lbs. The slugs are suitable for storage until they can be transferred ashore for disposal or discharged over-board where this is permitted. A solid waste pulper has been designed to safely reduce shipboard galley wastes, paper wastes, and classified documents into a neutrally or negatively buoyant, biodegradable, homogenous slurry for discharge overboard in non restricted waters. The pulper will process trash fed either loosely or in bags at a rate of over 500 lbs per hour.

A report [14] titled *Money Overboard* states in part "The US Navy has wasted more than $26 million on developing systems for processing waste at sea so that its ships will not have to throw it overboard."..................."But a congressional report released last week revealed that Navy officials put the research on hold last year after estimating that it

would cost $901 million in the next five years to fit its ships with the necessary equipment". This is a rather sobering comment that warrants further inquiry by AMRL, especially as to which equipment it refers.

The RN has found that neither incineration nor shredding/maceration alone are ideal for surface ships, but combined together into fully automated systems may be practicable for larger ships. A system incorporating a Hamworthy Neptune incinerator and a Metal Box shredder is currently undergoing trials for subsequent fitting to HMS *Illustrious* in her forthcoming refit. Existing pulping machines for paper and card, which are already fitted to larger ships, may be modified to be less susceptible to blockage, in line with results obtained by the USN during extensive trials. Compaction is being evaluated for ships of frigate and destroyer size or smaller and it is envisaged that purpose-built high density machines will achieve a garbage volume reduction in the order of 8:1 or better. MOD assessments indicate that a standard rugged compactor system will provide significant savings on training, maintenance, spare holdings and number of installations, when compared with the incinerator-based systems [10].

The USN participates in NATO Sub-Group 6 (SG/6) on Pollution Abatement and Disposal of Hazardous Materials and Hazardous Waste in Respect to Naval Vessels. This is a sub-group of the Information Exchange Group 6 (IEG/6) on Ship Design. Through this forum the USN is actively discussing a cooperative strategy for addressing pressing global marine environmental requirements with participating NATO Navies [13].

6. Design Considerations and Constraints

In addition to the operational requirements for waste handling equipment, design criteria specific to ship installation and operation needs to be considered. Smookler and Alig [13] listed some of the constraints in relation to the USN program as follows:

- size, weight and space limitations;
- reliability and maintainability requirements;
- safety and health considerations;
- manning limitations;
- shock, vibration and electromagnetic compatibility requirements;
- airborne and structure-borne noise requirements;
- limitations imposed by available ships' services and the shipboard operating environment;
- costs of acquisition, operating, and maintenance must be reasonable and justifiable.

The facilities required for off-loading, quarantining and disposal of processed waste, at both home and foreign ports, have to be determined. Safety and damage control considerations need to be taken into account when storing plastics waste because once ignited, it has a high heat output as well as giving off poisonous, corrosive fumes and copious amounts of smoke.

In view of the need to refrigerate food-contaminated wastes it has been suggested that the ship's freezer would be suitable. However this would probably have to be a dedicated compartment because of health regulations.

The USN found [13] that commercial waste processing equipment, even that designed for operation aboard commercial ships, often does not meet Navy requirements for performance and reliability. Difficulties have been encountered in duplicating the source and characteristics of shipboard waste, and for these and other reasons, it has been found that evaluation aboard Navy ships at sea is critical to the design process. Clearly a design specification incorporating the special requirements of Navy ships is required at the outset of these projects.

7. Processes Available for Disposal of Garbage Aboard Ships

7.1 Thermal Compaction.

This process is specifically designed for processing plastics waste and involves heating the compressed material to the point where melting and fusion occurs. The fused block of material is then cooled sufficiently to allow removal from the machine then another cycle is commenced. The depth of fusion can be regulated by the applied heating time and temperature and can vary from a few millimetres (sufficient to just hold the compressed material together) through to complete fusion of all the material charged into the chamber. If compaction is preceded by shredding, volume reductions up to 40:1 can be achieved. Segregation of the plastics material from non fusible material is required and recycling is feasible if the plastics have been sorted into generic types. Thermal compaction is a comparatively slow batch process and since fumes are likely to be given off, positive ventilation from the compartment is required. A review [2] of the various disposal processes applicable to plastics waste concluded that thermal compaction would be the best method because it not only reduced the bulk of plastics aboard but also sterilised it for safe storage (without containerisation) prior to disposal onshore. However, there remains some doubt whether or not the centre of the block is completely sterilised. No doubt this would depend on a number of factors including the processing time and temperature, the thickness of the block, degree of food contamination and the nature of the material processed.

7.2 Compactors.

Compaction, usually by hydraulic pressure, is the most common method of processing garbage and many machines are available. Volume reduction is generally low, at about 5:1, unless preceded by shredding. The compacted product may be secured in a variety of ways including tying off with cord, wire or tape to form a bale, containment in plastic bags of varying thickness and vapour barrier properties, and containment in sealed metal cans, garbage bins, or wheeled-bins. The machines are easy to clean and maintain, the process is quick and simple and there are virtually no restrictions on the composition of the garbage. There are multi-compartment compactors available that allow the segregation of garbage and utilise a common compression head that can be moved from one compartment to another. This then allows plastics materials to be retained while some other garbage can be disposed of overboard in appropriate waters. For smaller vessels with limited space that spend the greatest part of their operational time in restricted waters, commercially available compactors may provide the best solution [9].

7.3 Shredders.

Most shredders consist of two counter-rotating shafts fitted with a series of closely meshing multi-hooked blades that may also mesh with fixed cutter blades on the body of the machine. Waste is reduced to small pieces that can then pass through a screen to give a uniform product. Shredders can reduce most forms of dry garbage, including metal cans, bottles, plastics, or wood, to about 20% of original volume. This saves storage space, produces a product amenable to automatic handling methods and allows some items, which may otherwise float due to contained air or gas, to be dumped overboard when regulations permit. Disadvantages of shredders include their propensity to be clogged by plastics film, cloth, and wet materials, and for the mechanism to be jammed by large metal objects such as tools. They are complex machinery and are extremely difficult to clean.

7.4 Comminuters.

These appliances macerate and pulp galley food waste, paper and cardboard (including disposable cups, plates and plastics cutlery) and compress the material to about 15% of its original volume

In the comminuter fitted to ANZAC class frigates (manufactured by Hobart GMBH), waste is conveyed via a feed-in chute into a water filled pulper. A grinder disc is located at the bottom of the pulper and, by rotating at high speed, creates a vortex, drawing the water and waste down towards the blades. Soft and hard particles are cut, shredded or broken up by either the grinding disc or the blades. The water circulation transports the waste to the surface where it is again caught in the vortex and the cycle repeated until waste is reduced to a particle size small enough to pass through the sieve ring at the side of the grinding disc. The waste is then carried, with the process water, directly to the water-press, which is a screw conveyor within a strainer cylinder. Much of the process water is squeezed out of the pulped waste in

the water-press and returned by pump to the pulper. The waste, now reduced to a semi-dry, loose granulated form, is delivered from the outlet chute to a waste container or bag. At the end of the operation the process water is classified as garbage and may be treated in the ships sewage system.

These machines are ideal for galley waste and allow its discharge to unrestricted waters provided no plastics are included. When processing is complete any remaining water must be treated as the appropriate category of garbage, according to RAN policy. Although plastics film could cause clogging, this machine may offer the possibility of processing other food contaminated plastics (eg. polystyrene foam) giving a product that essentially has been washed and therefore could be stored with less likelihood of putrefaction.

7.5 Incinerators.

Incinerators have historically had a poor image but this perception is no longer valid. It stems, in part, from the performance of early designs that were inefficient, hard to maintain, and produced copious amounts of ash and emissions of dubious composition. However, modern designs are of multi-chamber construction, burn at closely controlled high temperatures (900-1200°C) and give almost complete combustion of most forms of waste including all categories of garbage (except metal and glass), sewage treatment residue and oily water waste containing up to 40% water. The remaining ash and clinker can be conveniently stored onboard for disposal at sea when permitted or returned to shore. Incinerators can be fully automated into a waste handling facility if the waste products (which can include glass and metal food and beverage containers) are pre-shredded. These systems are particularly suited to large ships. There can, however, be problems with burning certain materials such as plastics that burn at high temperatures and can give off toxic and corrosive gases. Indeed, there is a possibility that burning synthetic materials at sea may be prohibited by future international agreements [10]. Other problems with incinerators include the possible generation of dust and smoke within the operating compartment and difficulties in routeing the flue gases.

Standard specifications [15] for shipboard incinerators have been incorporated into MARPOL which detail how incinerators should be designed, constructed and operated.

8. Survey of Commercial Garbage Disposal Machinery

A global survey of garbage disposal machinery suitable for use aboard ships included commercially available machines, some of which are already in service in other navies and some which are still being developed. The survey was assisted by a literature search [11] and responses received from 18 companies in the form of brochures and reports. In a number of cases, company representatives visited AMRL to discuss their

products while in others on-site demonstrations were provided. The waste disposal facilities being installed on the new ANZAC frigate by Transfield Shipbuilding Pty. Ltd. at Williamstown were inspected and details of the machinery obtained. Appendix 1 summarises the information on 55 machines and includes such details as electrical requirements, construction materials, type of waste processed, process capacity, end product, dimensions, weight and cost. Details of the suppliers and Australian agents of the various machines are listed in Appendix 2.

8.1 Plastics Waste Processing Machines (Thermal Compaction).

(a) **The Thermopers Thermal Compactor** (Appendix 1, No. 5.01) appears, at present, to be the only machine immediately available but it is not specifically designed for marine use and therefore would require evaluation against a design specification. This equipment is made in Holland and imported by a Sydney-based company. An earlier model has been examined in service at Coles-Myer where it is being used successfully to compress packaging film into blocks held together by a thin fused skin of the film. The main improvement with the latest model, which is presently being evaluated by the local agent, is a change to hydraulic rather than mechanical compression. This machine is capable of processing 6 kg of plastics waste in a 25 minute cycle and therefore could handle the plastics waste produced by the largest RAN ships, ie. DDG destroyers (33 kg/day), amphibious heavy lift ship with 550 troops (55 kg/day) and training and helicopter support ship in amphibious mode (65 kg/day). The machine dimensions (730 mm wide*520 mm deep*2000 mm high), weight (175 kg), price ($9100) and the manufacturer's claim that there are no emissions, appears to make it a proposition for smaller ships. However, it remains to be seen whether the maximum heating temperature of 150°C, and adjustable heating cycle, will be sufficient to sterilise and seal food-contaminated mixed plastics waste sufficiently for extended storage. The painted mild steel cabinet may also need upgrading for marine use. Modifications to the machine could possibly be negotiated.

(b). **The Mobil Densifier (Thermal Compactor),** (Appendix 1, No. 6.01) which is being developed in the USA, was originally considered promising [2] but the company has not responded to several requests for additional technical information. This machine has a temperature range of 177-204°C and is loaded incrementally (15/20 minute intervals with heat applied) to maximum capacity when a warning light signals start of the baking cycle which is one hour. This combination of baking time and temperature is sufficient to completely dry out residual food matter and make it bacterially inert. Meanwhile moisture and fumes are controlled by an internal air sweep and vented through an exhaust stack. At the end of the baking time the full pan is removed through a bottom door and replaced with an empty one ready for the next cycle. After cooling, the 11-14 kg block can be tipped from the pan and stored for later disposal onshore. Stainless steel has been used as the main construction material and an inner cooling system ensures low surface temperatures. Processing capacity would be sufficient for the largest RAN ships while its size and weight (yet to be notified) will determine whether it is suitable for smaller craft. The projected cost was originally given as US$ 5000-7000.

(c). **The Strachan and Henshaw shredder/compactor/heat sealing plastics waste processor** (Appendix 1, No. 9.02), is being developing to MoD requirements for the RN. It is capable of a 40:1 volume reduction to produce a cylindrical disc (250 mm diameter * 50 mm) weighing about 15 kg and heat sealed to a depth of approximately 4 mm. The MoD specification stated that the plastics waste could contain residual food matter, and therefore the machine must seal this waste without containerisation to prevent the growth and spread of harmful bacteria for a period of at least 45 days. Further details on this machine are being sought, including details of a second machine being developed to similar specifications to process unsorted garbage aboard ships (see below).

8.2 Mixed Garbage Processing Machines.

Some machines can process mixed garbage, or segregated plastics waste, then seal the compressed product in plastics bags or other receptacles. The feasibility of this procedure will be examined with concern centering on the effectiveness of sealing food contaminated waste during extended storage. As there is a range of these machines commercially available, this approach may enable better matching with requirements of individual ships.

(a). The most elaborate and purpose built of these (Appendix 1, No. 9.01) is being developed by **Strachan and Henshaw** for the RN. The garbage is shredded and compressed then inserted into a metal can, fitted with a sealed lid and stored for disposal onshore. The advantage of this procedure is that no segregation of materials is required and it enables extended operation in special areas where a zero garbage discharge policy applies. During trials by Strachan and Henshaw [16], food contaminated waste was processed, sealed in a metal can, then stored for 10 weeks without any leakage or change in weight. This machine weighs about 2500 kg and has a budgetary cost around A$300,000.

(b). The **Milldale Pulvermatic 42-40 Clean Ocean Dispenser** (Appendix 1, No. 14.01) shreds all solid waste then compresses it into a perforated thin gauge mild steel container (designed for ejection through submarine waste outlet tubes). Provided the compaction density is at least 1065 kg/m^3 the container will then sink. An advantage of this machine is that it is designed for confined spaces. Non-perforated containers with sealed lids could be developed and adopted for use on surface ships.

(c). Machines which give the option of compacting and storing waste in plastics bags are the **Pakall** (No.s 1.01 & 1.02), **Autopressen Kompakt** (No.s. 1.03, 1.04, 1.05), **Autopressen Maxi** (No.s. 1.06, 1.07), **Autopressen KNL** (No.s 1.09, 1.10, 1.11, 1.12), **Mess-Press** (No.s 7.01, 7.02, 7.03), **Elephant's Foot** (No. 11.01), **Orwak** (No.s 12.02, 12.03), **Fox Pollution Packers** (No.s 13.01-13.07), **Milldale Excalibur** range (No. 14.05) and the **Disperator** range (No. 15.02) which includes one refrigerated model. These machines are produced in a range of sizes, including some suitable for smaller vessels. They allow processing of mixed garbage including plastics. However, it is doubtful whether simply tying off a standard plastics garbage bag would be sufficient to

contain gases from putrefaction over any length of time. This aspect, along with the permeability of various bag materials, would need to be investigated. Safe storage facilities below decks that allow for movement of the ship, would be required for the filled bags or rigid stackable containers.

(d). Machines that offer the option of compacting and storing the compressed garbage in containers such as wheeled-bins, garbage bins and metal bins include the **Autopressen FP 5** (No. 1.08), **Auspac 240** (No. 8.01), **Elephant Foot** (No. 11.01) and the **Orwak 4000 and 5030 Marine** (No.s 12.01, 12.02). These containers are more resistant to perforation than plastics bags and could perhaps be modified to incorporate a sealed lid to retain gases given off by the garbage. Most ships already carry *Sulo* or *Otto* mobile garbage bins which could be used with some of these machines.

8.3 Incinerators.

Incineration should also be considered as the technology has now become quite sophisticated and automated systems are being fitted to larger vessels such as cruise liners. Apart from any other considerations, the size and weight of most commercial incinerators preclude their use aboard any RAN ships smaller than destroyers or frigates that produce 633 kg and 310 kg of garbage per day respectively. One incinerator (referred to as a heat plant by the manufacturer) reviewed at this stage, ie. the **Waterwide DF80** (Table 3, No. 2.04), has dimensions 2300 mm wide*2200 mm deep*2500 mm high, weight 3500 kg and can consume 400 kg/h of kitchen waste. In the **Kvaerner-Golar** incinerator range (Table 3, No.s 16.01, 16.02), the smallest model (OG 120) has dimensions 912 mm wide*912 mm deep*1845 mm high, weight 1350 kg solid waste consumption rate of 200 litres per charge and emissions that meet MARPOL requirements [15]. **Norsk Hydro** (Table 3, No. 17.01) and **Deerberg** (Table 3, No. 18.01) manufacture fully integrated waste disposal plants that have an incinerator as the centre piece and are particularly suited to cruise liners. Incineration for RAN ships is the subject of a detailed review presently underway.

9. Conclusions.

9.1. The RAN has very few ships large enough to warrant a sophisticated garbage disposal system. There will be a need to tailor garbage processing systems to suit the size, complement and function criteria of individual vessel classes.

9.2. When making long term decisions about appropriate waste disposal machinery it should be recognised that trends are towards minimal disposal of waste at sea and already there are a significant number of declared 'Special Areas' where stringent waste disposal requirements apply. The Great Barrier Reef Region has been designated a 'Particularly Sensitive Sea Area' and here no garbage of any type may be discharged.

10. Recommendations (prioritised).

1. Incineration will be considered as the technology has been developed to a sophisticated level and offers an integrated waste disposal facility for mixed garbage and waste oil. It would also have the potential for disposing of residue that may be an end product of future ship sewage treatment systems. Although weight, space, heat generation and cost requirements are high, the advantages of this system are its ability to meet zero discharge requirements (other than flue gases) producing a minimum of residue that does not require quarantine procedures when disposed of ashore.

2. Garbage accumulation rates and classifications (additional to food waste) should be verified by AMRL/RAN for a range of ship classes as this will determine management procedures and the choice of disposal machinery, particularly for smaller craft.

3. The compactor being developed by Strachan and Henshaw for the RN (Appendix 1, No. 9.01) may be suitable for processing garbage on larger craft such as training and helicopter support ships and auxiliary tankers and should be further investigated by the RAN (MPCP) with a view to a trial. Even though the machine weight and cost are high, further investigation by the RAN is warranted as these machines would enable extended operation in areas where a stringent garbage discharge policy applies.

4. The Milldale Pulvermatic 42-40 Clean Ocean Dispenser (Appendix 1, No. 14.01) is worthy of further inquiry by AMRL. This machine is a cheaper and smaller alternative to the Strachan and Henshaw unit that utilises a similar process.

5. Many commercial compactors compress garbage into plastics bags. The effectiveness of sealing the bag and the permeability of the bag material to gases produced by putrefaction, should be investigated by AMRL. These machines are available in a range of sizes, some of which suit smaller craft.

6. The Disperator UKP 7070 refrigerated compactor (Appendix 1, No. 15.03) may assist the storage of food contaminated plastics waste and garbage and should be investigated further by AMRL to see if trials by the RAN are warranted.

7. The Thermopers thermal compactor (Appendix 1, No. 5.01), modified for marine use, may be suitable for processing plastics waste aboard Navy ships and should be investigated further by AMRL if plastics segregation is feasible.

8. AMRL should obtain detailed information from the RN, USN and RCN on trials of the more promising shipboard garbage disposal equipment.

9. Some machines, such as the Auspac 240 and the Orwak 4000 (Appendix 1, No.'s 8.01 and 12,01 respectively), compact garbage into mobile garbage bins or metal containers and are therefore worth investigating, particularly since most RAN ships

are already equipped with these bins. The possibility of developing a sealing lid for a mobile garbage bin, for use in conjunction with chemicals that reduce garbage putrefaction and infestation by insects, should be discussed with manufacturers by AMRL.

10. At face value, the Elephant's Foot Waste Compactor (Appendix 1, No. 11.01) is a promising machine. It is being installed in the new ANZAC class frigates to compact garbage into sealed plastics bags, but it is reported to have a doubtful reputation with some RAN personnel, and therefore needs closer scrutiny by AMRL.

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Appendix 1: Technical Details of Garbage Disposal Machinery (Information current at January 1995)

Appendix 1

(Refer Appendix 2 for Supplier Names and Addresses)

Technical Details of Garbage Disposal Machinery
(Information current January, 1995)

No.	Machine Name Model	Voltage (V)	Power (kW)	Construction material	Process Capacity	Waste type	Final product	Typical application	Dimensions W * D * H (mm)	Hopper opening (mm)	Weight (kg)	Budgetary cost ex tax (A$)	Notes (see page 25)
	Pakall (Compactors)												
1.01	75	240	0.75	Stainless steel	20-30 kg per batch	Food, cartons,	540*435*315 mm	Food Industry	610*525*1510	510*330		9600-11800	1
1.02	150	240	1.5	Stainless steel	25-35 kg per batch	Packaging	630*680*500 mm sealed in PE bag	Hospitals	760*660*1680	700*425	320	13100-16400	1
	Austropressen (Compactors)												
1.03	Kompakt K50	415/ 240	1.1/ 1.1	Mild steel	20-60 kg per batch	Cartons, cans, plastics	500*400*400 mm	Shops, hotels,	750*900*1850	500*400	280	5800	2
1.04	Kompakt K65	415/ 240	1.1/ 1.5	Mild steel	30-80 kg per batch	Cartons, cans, plastics	650*450*450 mm	garages	900*1050*1900	650*450	350	6600	3
1.05	Kompakt K70	415/ 240	1.5/ 1.5	Mild steel	40-100 kg per batch Comp. ratio 1:20	Cartons, cans, plastics	700*550*500 mm		950*1150*1950	550*700	430	7500	3
1.06	Maxi	415/ 240	1.1	Mild steel		Cartons, cans, plastics	750*450 mm dia.	Food Industry. hotels,	860*1200*1950	450 dia.	310	8300	4
1.07	Maxi LC	415/ 240	1.1	Mild steel		Cartons, cans, plastics	600* 450 mm dia.	hospitals	860*1200*1800	450 dia.	290	8300	5
1.08	FP 5	415	1.1	Mild steel	200 litre per batch	Medications, cans, plastics, cleaning rags	Compacted in 200 l drum	Food Industry. hotels, hospitals	850*1030*2000		145		6
1.09	KNL 80	415	3	Mild steel	50-100 kg per batch	Cartons, cans, plastics	550*600*700 mm	Industrial waste	1050*3000*1030	550*600	580	13500	7
1.10	KNL 100	415	4	Mild steel	60-120 kg per batch	Cartons, cans, plastics	550*1200*700 mm	Industrial waste	1050*3800*1030	550*1200	750	15500	7
1.11	KNL 120	415	4	Mild steel	60-130 kg per batch	Cartons, cans, plastics	600*700*800 mm	Industrial waste	1050*3400*1150	600*700	980	18000	7
1.12	KNL 140	415	5.5	Mild steel	120-150 kg per batch	Cartons, cans, plastics	600*1200*800 mm	Industrial waste	1050*4400*1150	600*1200	1200	19500	7
	Brentwood (Shredders and Shredder/Compactors)												
2.01	AZ15W-7.5kW (High- torque model)	415	7.5	Alloy steel	12 m3/h	Plastics, boxes, drums	Shredded	Plastics industry	1800*1000*2356	1000*800	600	37689 del. & inst	8
2.02	Shred-N-Pak SP10	415	7.5			Plastics, glass, cans, paper	Shredded & comp.	Industrial, institutional	920*1030*1850	730*625	705	6900	9
2.03	Shred-N-Pak SP15	415	15			Plastics, glass, cans, paper	Shredded & comp.	Industrial,- institutional	2590*965*1992	1047*650	705	7500	10

Appendix 1

(Refer Appendix 2 for Supplier Names and Addresses)

Technical Details of Garbage Disposal Machinery (Cont'd)
(Information current January, 1995)

No.	Machine Name Model	Voltage (V)	Power (kW)	Construction material	Process Capacity	Waste type	Final product	Typical application	Dimensions W * D * H (mm)	Hopper opening (mm)	Weight (kg)	Budgetary cost ex tax (A$)	Notes (see page 25)
	Waterwide (900 kW Heat Plant)												
2.04	DF80		10 (fan)	Refractory & ceramic fibre insulation	400 kg/h kitchen W. 200 kg/h dry timber	Solid fuel (Plastics etc.)	Burnt fuel gases& 0.25 / 7% fine ash	Industrial, farms, plantations	2300*2200*2500	1000*800 ?	3500	91000 del. & inst.	11
	Macquarrie (Chipper - Shredder)												
3.01	15	Various	20/30	Machined cast steel	40/50 kg per h timber	Plastics, paper, wood(no metal)	Small chips	Industrial, municipal	Chipper head 300*300*400 plus feed syst. & frame etc.	250*150 dia.	100 (head) plus acc.	9300	12
	Satrind (Shredder)												
4.01	F515	220/380 /440	11		200-500 kg per h	Plastics, metal, catering waste	Shredded chips	Industrial, institutional	1232*865*2180	620*488	1350	37599 del. & inst.	13
	Thermopers (Thermal Compactor)												
5.01	New model	220-240	3.3	Sheet metal body, Components of appropriate materials.	6 kg per batch ~20 minute cycle	Thermoplastics except hard types (150 °C max.). No wet waste	600*300*100 mm compressed block with skin 4-5 mm	Vol. reduction plastics film waste	730*520*2000	600*200	175	9100	14
	Mobil (177-244°C Thermal Compactor)												
6.01	Mobil Densifier	240	8	Stainless steel	11.4 - 13.6 kg / batch, add incr. @ 10-15 min bake 1 h when full	Thermoplastics, food serviceware	solidified block 11.4-13.6 kg	Institutional, restaurants	3.53 m^2 floor sp. 3.05 m ceiling ??			US$ 5/7000 projected	15
	Mess-Press (Compactors)												
7.01	2000	240	0.37	Stainless steel 304	75 litre, 40 kg dep. on waste Red. to 10% vol.	Cartons, tins, bottles, crates, wet kitchen waste.	530*460*480 mm bale in PE bag Press. 2000 kg	Hospitals, hotels, factories, fast-food, out-doors	560*480*1600		225	9,988	16
7.02	4000	240	0.75	Stainless steel 304	75 litre, 60 kg dep. on waste Red. to 10% vol.	Cartons, tins, bottles, crates, wet kitchen waste.	530*460*480 mm bale in PE bag Press.4000 kg	Hospitals, hotels, factories, fast-food, out-doors	560*480*1700		265	11,750	16
7.03	6000	240	1.1	Stainless steel 304	120 litre, 100 kg dep. on waste Red. to 10% vol.	Cartons, tins, bottles, crates, wet kitchen waste	730*660*660 mm bale in PE bag Press.6000 kg	Hospitals, hotels, factories, fast-food, out-doors	760*680*1800		360		17

Appendix 1

(Refer Appendix 2 for Supplier Names and Addresses)

Technical Details of Garbage Disposal Machinery (Cont'd)
(Information current January, 1995)

No.	Machine Name Model	Voltage (V)	Power (kW)	Construction material	Process Capacity	Waste type	Final product	Typical application	Dimensions W * D * H (mm)	Hopper opening (mm)	Weight (kg)	Budgetary cost ex tax (A$)	Notes (see page 25)
	Auspac (Compactor)												
8.01	240	240/ 415	2.2/ 2.2	Mild steel/ baked enamel SS panels Opt., HD coat. for marine	5:1 comp. into 240 l wheeled bin	Wet/dry kitchen, tins, cartons, plastics etc.	Compacted in 240 l wheeled bin	Hospitals, hotels, factories, fast-food, shipping lines.	760*1065*1975		350		
	Strachan & Henshaw (Shredder - Compactor and Shredder - Compactor - Heat-seal)												
9.01		440		Modular construction.	3.4 m3/h Vol. red. 15:1	Mixed waste incl. plastics or all plastics	Sealed m.s.can 300*300 mm dia 15 kg wt.full.	Specialist shipboard use	2000*700*2000		2500	300 000	18
9.02					Vol. red. 40:1	Plastics	50*250 mm dia. block, 4 mm skin 15 kg wt	Specialist shipboard use					18
	Hobart Garbage Comminuter (Shredder - Compressors)												
10.01	Anzac Ecolo 251 R/L	380/ 50/ 3	7.8	Stainless steel	250-350 kg per hour	Galley waste, disp. plastics cutlery & plates	Loose granulated 85% vol. red.	Ships galley	2320*900*1970		640	58 000 ?	19
10.02	Mini Ecolo FD 500 (with separate water press)	440		Disposer cast steel, Water press stainless steel	250 kg per hour	Galley waste (not bones)	Loose granulated 85% vol. red.	Ships galley	Adj. ht. to 990 Water press 800*1450*1650	457 or 381 cone	150, water press 400		
	Elephant Foot Waste Compactor (Compactor)												
11.01	H/D 2/2N	440	4	5 mm mild steel plate or stainless steel	0.221 m3 charge 70 s cycle time Vol. red. 20:1	General shipboard & household waste, cans, bottles, etc	Compacted blocks into 76 l garbage can or equivalent bag	General garbage compaction	2330*700*1500 compactor 990*320*700 power pack	450*406	400, power pack 70	11 000	19
	Orwak (Adjustable Compactor, Compactor and Compactor/Baler/Crusher)												
12.01	4000	220	0.75		25 s cycle	Boxes, cans, etc.	80% vol. red. into 120, 140, 240, or 360 l wheeled bins	General garbage compaction	857*700*1960	As per wheeled bin	265	6 569	20
12.02	5030 Marine (5030 BMT)	Range of 1 & 3P	0.75		30 s cycle	wet & dry kitchen ref., tins, the odd glass, packaging material	85 % vol. red. into H.D. 160 l plastic bag, 15-30 kg	General garbage compaction	780*980*1470 2040 emptying pos.	500 dia.	310	9 238	21
12.03	5031 (X 5031 A)	220 or 110			30 s cycle (max.)	Comp.moist & dry ref. Bales cardboard, paper & plastics.	Comp. into plastic bag or baled & tied 500*500*500 mm 20-40 kg	General garbage compaction	780*980*1940 2660 emptying pos.	500*500	340	8 134	22

Appendix 1

(Refer Appendix 2 for Supplier Names and Addresses)

Technical Details of Garbage Disposal Machinery (Cont'd)
(Information current January, 1995)

No.	Machine Name Model	Voltage (V)	Power (kW)	Construction material	Process Capacity	Waste type	Final product	Typical application	Dimensions W * D * H (mm)	Hopper opening (mm)	Weight (kg)	Budgetary cost ex tax (A$)	Notes (see page 25)
	Fox P.P. (Compactors, Bottle Breaker and Crusher)												
13.01	1600 SS	110, 220		Critical parts stainless steel	15/19 s cycle	Typical ship's waste		Aboard ships	530*521*1580	400*318	205		
13.02	1800 SS	Range of S & 3P		Stainless steel	8:1 & 15:1 comp. ratios 18 to 22 s. 6250 kg comp. force	Typical ship's waste, Plastics packaging	475*440*470 mm in plastic sack in cardboard box	Aboard ships, general waste to 10 % liq. content	625*554*1807	525*380	260	UK£ 5000	23
13.03	1800 LM	Range of S & 3P		316 stainless steel	up to 20:1 comp. ratio 6 ton press.			Mine hunter/ sweeper vessels				UK£ 12500	23
13.04	2400 SS	Range of S & 3P		Critical parts stainless steel	18/22 s cycle time	Typical ship's waste		Aboard ships	714*706*1933	610*445	305		
13.05	Unipac Mini	240		Std. white or stainless steel. finish	24 l bin, 2 tonne press.	Kitchen garbage	Sealed in plastic	Kitchen/galley	345*460*670		60		
13.06	Unipac Standard	240		Std. white or stainless steel finish	35 l bin, 2 tonne press.	Kitchen garbage	Sealed in plastic	Kitchen/galley	340*600*850		68		
13.07	Unipac Maxi	240		Std. white or s.s. finish	90 l bin, 2 tonne press.	Kitchen garbage	Sealed in plastic	Kitchen/galley	500*600*850		80		
13.08	Bottle/glass breaker	240			240 l bin, 75 % vol. red.	Glass bottles incl. 5 l	Glass fragments	Kitchen/galley	647*889*2006				
13.09	Kan Krusher	Manual		Painted finish	80 % vol. red.	Std. aluminium cans	< 25 mm can ht.	Mess rooms etc.	125*100*400				
	Milldale (Shredder-Compactors, Shredders, Bailers and Compactor-Bailers)												
14.01	Pulvermatic 42-40 Clean Ocean Disp.	4403 phase		S.steel hopper& clam-shell cylinder	Shredder 75-180 kg/h	Ships solid garbage, cans, glass, plastic	Sea-bed container 606*224 mm dia.	Submarines ships,	607*781*1588 mm		910		24
14.02	Marine shredder range eg. PL4220	380/440 3 phase	Var.	Hardened alloy steel cutters		Glass, cans, wood, plastic containers	80 % vol. reduction	Various size Navy ships					25
14.03	Excalibur multi-bin baler range												26
14.04	Excalibur vertical baler range												26
14.05	Excalibur compactor/ bagger range												26

Appendix 1

(Refer Appendix 2 for Supplier Names and Addresses)

Technical Details of Garbage Disposal Machinery (Cont'd)
(Information current January, 1995)

No.	Machine Name Model	Voltage (V)	Power (kW)	Construction material	Process Capacity	Waste type	Final product	Typical application	Dimensions W * D * H (mm)	Hopper opening (mm)	Weight (kg)	Budgetary cost ex tax (A$)	Notes (see page 25)
	Disperator (Bailing Press, Compactors and Glass Crusher)												
15.01	DBP												
15.02	TT 160	240 etc.	0.75	SS on mild st. frame	10 sec. cycle	Refuse, cardbd., etc.	400*400*330 mm	Commercial	530*500*1530	428*327		10346	27
	TT 180	240 etc.	0.75	SS on mild st. frame	22 sec. cycle	Refuse, cardbd., etc.	475*500*475 mm	Commercial	625*570*1790	513*317		11746	28
	TT 240	240 etc.	0.75	SS on mild st. frame	23 sec. cycle	Refuse, cardbd., etc.	500*600*600 mm	Commercial	715*715*1940	610*418		12473	29
	KP 7, 30-57, 8251						Compressed in plastic sack						
15.03	UKP 7070 (Refrigerated)	220,380, 440	2.5	Casing SIS 2333 18/8 Chamber & frame epoxy-enamelled		Mixed garbage, food waste, boxes, cans, plastic, packaging.	600 mm cube in plastic sack wire-sealed	Catering, marine	700*700*1980 Heights to 1500 by request	500*500	260 net 290 gross	15273	30
15.04	Food waste disposer 5 models												31
15.05	Shredders												
15.06	GKF 350					Glass bottles	Glass fragments						
	Kvaerner-Golar (Incinerators)												
16.01	OG 120				180,000 kcal/h (210 kW) Solid waste 200 l/ch.	Liquid & solid	Ash	Shipboard	910*912*1845		1,350		32
16.02	OG 200,OGS 200 OG 400, OGS 400 GS 500, GS 500 AL				400 l/ch., Cont. 400 l/ch., Cont., Cont., Cont./Auto	Mixed shipboard	Ash						
	Norsk Hydro (Incinerator)												
17.01	NH-600-SG-S				110 kg/h	Mixed shipboard	Ash	Cruise ships	4200*1800*2620		12,800		33
	Deerberg (Incinerator)												
18.01	Multi purpose waste management system					Mixed shipboard	Ash, metal & glass	Cruise ships					

Notes.

1. Unsuitable for plastics alone but have been supplied to cruise liners for processing kitchen garbage.
2. Can be fitted to bale into plastic bags.
3. Two, three and four bin versions allow sorting waste.
4. Height during changing bag 2550 mm.
5. Height during changing bag 2250 mm.
6. Uses waste 200 litre drums.
7. Bagging attachment allows containment of bale in plastic bag.
8. Will customise. Examples at Improdex (9376 1133) and Britax (Bruno Bolli, 9311 0611).
9. Compactor 1.1 kW. Example at Coles Myer, Burke St., Melbourne.
10. Compactor 2.2 kW.
11. Disposal of waste from shredder etc., example at Currie, King Island (Frank Cullen, 004 621 340).
12. Demonstration could be arranged at Macquarrie.
13. Can see machine, samples and video at C.T.S.
14. Controlled by built-in computer, heat applied on all sides of press, compacted block imprinted with No., no emissions, 600 kgF working pressure (hydraulic), max. heating temp. 150°C.
15. Dry & bacterially inert block of density 30/35 lbs/ft3. Vented through exhaust stack, inner cooling system ensures low surface temperatures.
16. Options: UV steriliser $730, Deoderiser spray unit, Shredder, flame proof, through wall chute feed, cube handling trolley $440, one roll/100 off plastic bags $275.
17. Options as above. Model 6000a can be horizontal.
18. Built to MoD requirements for the RN.
19. Installed in ANZAC class frigates.
20. Simplest if wheeled bins used on weather deck, can segregate waste using colour coded bins.
21. Metal, reusable accessory can used for compacting glass, cans & other refuse requiring strong packaging.
22. Others in 5000 series include 5070 multi-bin which allows segregation of waste. Also the larger 8000 series.
23. UV lamp to reduce bacteria, air purification system, IP55 splashproof rating.
24. Uses ship's hydraulic services, added local deck loading is 5400 lbs.
25. Ploughs fitted to prevent material build up between cutters, grills or screens below cutters, auto overload & anti-jamming, customised accessories, bag & conveyor attachments.
26. Details of this range being sought.
27. Designed for small spaces, compaction press. 3100 kg, polythene bag fitted into & around reusable bin.
28. Compaction pressure 4500 kg.
29. Compaction pressure 5000 kg.
30. Compaction force 5 tons (50 kN), Electrom brackets for welding to deck plate in marine application.
31. Can be fitted with compression & dewatering equipment to prepare food waste for eg. incineration.
32. Fully comply with IMO regulations, combustion temps. 900-1200 °C, auto. control & operation.
33. Automatic ash removal & feed system from storage hopper fitted with heavy duty shredder, 3 comb. zones 700-950, 850-1000 °C, 3 larger models available.

Appendix 2: Garbage Disposal Machinery Suppliers (Information current at January 1995)

Appendix 2

Garbage Disposal Machinery Suppliers
(Information Current January 1995)

Machine No. (ref App. 1)	Machine Name	Manufacturer or Supplier	Address	Contact	Telephone	Local Agent	Telephone	Contact.
1.01-1.02	Pakall	Portable Balers Ltd.	"Birmingham, UK"		021 554 7241	Mecal (Aust) West Footscray Vic.	(03) 9314 0144	David Rooney
1.03-1.12	Austropressen	Roither Maschinenbau	Germany			As above	As above	As above
2.01-2.03	Brentwood	Brentwood Shredders	"Wollongong, NSW, Aust."		(042) 714488	Shredding Systems "Nth. Fitzroy, Vic."	(03) 9486 1811	Howard Kerr
2.04	Waterwide	Waterwide International	"Hawke's Bay, NZ"		(06) 835 3113	As above	As above	As above
3.01	Macquarrie	Macquarrie Corp. Pty.Ltd.	"Campbellfield, Vic. Aust."	Alan MacQuarrie	(03) 9358 5555			
4.01	Satrind	C.T.S. Plastics M/c	"Huntingdale, Vic. Aust."	Stephen Picone	(03) 9544 1432			
5.01	Thermopers		Holland			Thermopers Pty. Ltd. "Baulkham Hills, NSW"	(02) 638 7179	Jeremy Cocks
6.01	Mobil Densifier	Mobil (US)	"Pittsford, New York"	Dr Richard Wenzel		Mobil Oil Aust. Ltd.	9252 3412	Kim MacMillan
7.01-7.03	Mess-Press	Hydra-Pac Pty.Ltd.	Wingfield Sth. Aust.	Mark Gray	(08) 262 3047			
8.01	Auspac	Lyco Industries Pty.Ltd	Beaufort Vic. Aust.			Pronique Aust.	9752 5111	David Collins
9.01-9.02	Strachan & Henshaw	Strachan & Henshaw	UK			Strachan & Henshaw "Regency Park, SA"	(08) 346 8921	Dave Bonner

Appendix 2 (cont'd)

Garbage Disposal Machinery Suppliers
(Information Current January 1995)

Machine No. (ref App. 1)	Machine Name	Manufacturer or Supplier	Address	Contact	Telephone	Local Agent	Telephone	Contact.
10.01-10.02	Hobart Garbage Comminuter	Hobart GMBH	"Offenburg, Germany"			Ultramarine Frontline "Dandenong, Vic."	(03) 9706 4788	Phil Kay
11.01	Elephant Foot Waste Compactor	Elephant Foot Waste Compactors Pty.Ltd.	"Mascot, NSW, Aust."	Harvey Michael	(02) 667 4881			
12.01-12.03	Orwak	AB Orwak	Sweden		46-382-123 00	Sun-Air (Aust.) Pty. Ltd. "Drummoyne, NSW"	(02) 819 7681	Jan Anger
13.01-13.09	See Appendix 1	Fox Pollution Packers	"Gloucester, UK"	Peter L. Cosgrif	44 452 731202	None		
14.01-14.05	See Appendix 1	Milldale Ltd.	"West Yorkshire, UK"	Crowther Laycock	(0484) 534214	None		
15.01-15.06	See Appendix 1	Disperator AB	"Skarpnack, Sweden"	Lars Holmqvist	46 8 724 01 60	Peters Equipment Div. "Blacktown, NSW"	(02) 834 2022	Alan Lowther
16.01-16.02	Incinerator	Kvaerner Incineration a.s	"Gjeving, Norway"	Jorgen Kyed	(47) 37 16 3222	None		
17.01	Incinerator	Norsk Hydro Waste Tr	"Notodden, Norway"	Johannes Akkerhaugen	47 35 01 7100	None		
18.01	Incinerator	Deerberg-Systems	"Oldenburg, Germany"	Gunter Laue	49-(0) 441 77 6062	Ultramarine Frontline	(03) 9706 4788	Phil Kay

DISPOSAL OF GARBAGE ABOARD RAN SHIPS
-A REVIEW OF POSSIBLE OPTIONS-

R.J. Roseblade.

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DGNES (Director-General Naval Engineering Services)

Project Design Managers

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HS PDM (Hydrographic Ship).
MHC PDM (Minehunter Coastal).
MHI PDM (Mine Hunter Inshore).
FFG PUP PDM (FFG Progressive Upgrade)
THSS PDM (Training and Helicopter Support Ship).
ANZACS PDM (ANZAC Ship).
SPD (New Submarine).
PPB PD (Pacific Patrol Boat).
MS PD (Minesweeper).
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19. ABSTRACT
The RAN is implementing procedures to dispose of shipborne waste based on national legislation in order to meet International Maritime Organization (IMO) requirements. The regulations, which only apply to navies when operational commitments allow, cover a number of categories of waste, including garbage. A summary of the RAN disposal regulations applying to various types of garbage and estimates of the amounts generated on the various ships are included. Existing garbage disposal equipment and procedures employed by the RAN and some research conducted by other navies have been reviewed. The processes available for disposal of garbage aboard ships have been studied and the design constraints applying to shipboard installations summarised. A comprehensive survey of garbage processing machinery that included thermal compactors for plastics materials, shredders, compactors, comminuters and incinerators was also conducted. The most promising machines for use by the RAN are discussed and recommendations for future actions by AMRL and the RAN are made.

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